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ABSTRACT

Evidence of high population density's serious inhibiting effects on the reproductive, aggressive, withdrawal and sexual behavior of various animals, motivated a study of human pathology in overcrowded areas. Ecological relationships in Chicago and their impact on human behavior were assessed. The number of persons per acre, Standardized Mortality Ratio, and General Fertility Rate were gauged, as were Public Assistance Rate for persons under 18 (a measure of ineffectual parental care), Juvenile Delinquency Rate, (a measure of aggressive behavior), and the Rate of Admissions to Mental Hospitals. Social class and ethnicity were also considered. Great differences were found between the different measures of population density: (1) Persons per room accounted for most of the variance for mortality, fertility, public assistance and juvenile delinquency. (2) For admissions to mental hospitals, rooms per housing unit accounted for virtually all the variance associated with density. (3) Number of housing units per structure was less important; rooms per housing unit and structures per acre appeared relatively unimportant. The causal relationship between density and pathology is discussed for each of the five pathologies. (KS)

Population Density and Pathology: What Are the Relationships for Man?

Evidence from one city suggests that high population density may be linked to "pathological" behavior.

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Population Density and Pathology: What Are the Relationships for Man?

Studies of various animal populations suggest that high levels of population density frequently produce 'pathological' behavior. The results of these studies coupled with an increased concern about high rates of growth in the human population, have led to speculations about the implications of high density for human populations. We begin this paper by a review of some of these studies, noting the implications of possible animal-human similarities. We then propose to take the animal studies as a serious model for human populations and devise a test case.

In 1962, John B. Calhoun published an article detailing the ways in which overcrowding affects the behavior of rats. In his experiment, there was sufficient food and water but the density of the population was substantially higher than that observed in the rats' natural habitat. Under these condictions Calhoun observed the following "pathological behaviors": increased mortality, especially among the very young; lowered fertility rates; neglect of the young by their mothers; overly aggressive and conflict-oriented behavior; almost total withdrawal from the community (the "somnambulists"); sexual aberrations and other "psychotic" behavior (1). It should be noted that these aberrations were much more common in the central pens, where the rats <u>voluntarily</u> congregated.

In recent years it has become clear that rats are not alone in being adversely affected by high levels of density. A few other examples will be noted (2). A study by Susiyama (3) of wild monkeys indicated that high density led to a general breakdown in the monkey's social order and resulted in extreme aggressive behavior, hypersexuality, the killing of

young, etc. High density appears to cause death in hares (4) and shrews (5). Morris (6) has experimentally shown high density to cause homosexuality in fish. Probably the most frequently demonstrated effect of density is in the area of natality. Under conditions of high density, for example, the clutch size of the great-tit decreases (7), as does the number of young carried by shrews (8). It appears likely that high density reduces the fertility of elephants (9). Female house mice abort if they smell a strange male mouse (10) as do shrews (11).

In sum, high population density appears to have a serious inhibiting effect on many animals. It must be noted, however, that the effect of density is not uniform among different species but that different species react to density in different ways. It is probably inevitable that as we come to understand the effect density has on animal behavior that we wonder about the effect density may have on human behavior. By now the idea that density has, or at least may have, serious consequences for man appears to have fairly wide acceptance. Such acceptance is obvious in much of the popular literature (12) as well as works specifically aimed at behavioral scientists (13).

Density and Pathology in Human Populations

Although there is a moderately large literature on the effect overcrowding has on human behavior, there is a paucity of good research. A detailed and careful review of the existing literature by Schorr led him to believe that the effect of poor housing (overcrowding) had been understated. From his review he concluded that poor housing (overcrowding) had the following effects:

"A perception of one's self that leads to pessimism and passivity,

stress to which the individual cannot adapt, poor health, and a state of dissatisfaction; pleasure in company but not in solitude, cynicism about people and organizations, a high degree of sexual stimulation without legitimate outlet, and difficulty in household management and child rearing..." (14). Other authors interpret the existing data differently and feel that such relationships have not, in general, been clearly established (15).

The evidence on the relations of pathological behavior and high population density is ambiguous, and before the issue is decided, a number of studies looking at different populations in different settings will have to be undertaken. If, as Hall (16) has suggested, different cultures and different ethnic groups have different spatial requirements the issue becomes quite complex. A recent and important interview study in Hong Kong suggested that within that culture and in that setting, where virtually everyone lives in an overcrowded environment, variations in crowding are not related to severe emotional strain but are related to a lack of control over children (17).

In the present study we will look at the relationship between population density and a variety of pathological behaviors as they vary over the community areas of Chicago (18). Even if we use the animal studies as a guide, it is not obvious what effects we should look for in humans for, as previously noted, density appears to affect different species in different ways. Our analysis will thus, of necessity, be exploratory. As Calhoun's study has received more attention than others, we use his results as a starting point. There are several pragmatic reasons for doing so. First, he found a wider range of "pathologies" than most studies which gives our investigation more breadth. Second, there are a number of indices in the

Chicago data which will serve as surrogate measures of Calhoun's pathologies. In particular, there are indices of a) fertility, b) mortality, c) ineffectual care of the young, d) asocial, aggressive behavior, and e) psychiatric disorder. In the following paragraphs, we will briefly present the operational definitions of the measures which will be used in the statistical analysis.

Operational Definitions. For each of the 75 Community Areas of Chicago, the Local Community Fact Book for Chicago (19) provides information on the number of persons residing in that area. This, combined with the size of the land area included in each Community Area (20) gives a measure of population density -- the number of persons per acre.

The first two measures we shall use for indices of "social" pathology are distinctly biological in nature -- mortality and fertility. The immediate cause of mortality will generally be specific diseases, although mortality rates will also include such variables as malnutrition, accidents and suicide. Variations in fertility are due to differences in conception, gestation,parturition, and the factors involved in these processes. However, as Calhoun noted, the factors involved in determining variations in mortality and fertility are largely "social" in nature. That is, although mortality is largely the consequence of disease, we are interested in variations in mortality as a social phenomenon because such variations appear to be indirectly caused by and certainly are associated with such variables as social class, ethnicity, and possibly population density. The same may be said for the factors involved in the determination of variations in fertility. Let us define, then, the first measure of social pathology as the Standarized Mortality Ratio. This measure is the age-adjusted death

rate of a given Community Area expressed as a ratio to the death rate for the total population of Chicago in 1960. Our second measure of social pathology will be the General Fertility Rate, which is simply the number of births in a Community Area per 1,000 women ages 15-44 in the same Area.

As a measure of ineffectual parental care of the young, we will use the Number of Recipients of Public Assistance under 18 years of age in May of 1962 per 100 persons under 18 years of age in April, 1960. Although not an ideal measure of ineffectual parental care, families receiving such assistance are typically disrupted, having only one parent in residence, and the family is not providing for the children in the normal societal manner. For ease of reference, we shall call this the Public Assistance Rate, but it should be remembered that the rate refers only to the young persons of the Community Area. Our measure of asocial, aggressive behavior will be the "number of male individuals brought before the Family Court of Cook County on delinquency petitions during the years 1958-61 per 100 male population 12-16 years of age in 1960" (21). Again, for simplicity's sake, we refer to the measure simply as the Juvenile Delinquency Rate. Finally, as an indication of withdrawal and other psychotic behavior, the Fact Book reports age-adjusted rates of admissions to mental hospitals for 1960-61 per 100,000 persons in the Community Area in 1960. This we shall call the rate of Admissions to Mental Hospitals (22).

Variations in the five "social pathologies" we have just defined are normally explained by social structure factors, such as social class and ethnic (or racial) status. For example, it is assumed that variations in the mortality rate arise from such factors as exposure to disease, access to medical assistance, and knowledge about effective preventive measures,

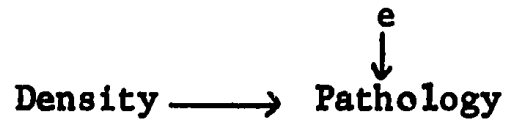
that such factors are mediated by one's class and ethnic position in the social structure. Similar arguments are made regarding the other pathologies. The precise explanation of the way in which class and ethnicity relate to each pathology would probably differ -- and in fact there may be more than one explanation of how class and ethnicity relate to a particular pathology. Nevertheless, most sociologists see these social structural variables as the main factors determining the variations in the rates of these pathologies. The case for the population density argument will be substantially strengthened if we can demonstrate not only that variations in population density make a significant contribution to the amount of variance explained in selected social pathologies, but that this contribution remains significant even after taking into account (or controlling for) the traditional sociological variables, social class and ethnic status.

As indicators of social class we have chosen three measures: the percentage of employed males in the Community Area who have white collar occupations; the median years of school complemented by all persons 25 years of age and older in a Community Area; and the median family income for all families residing in that Community Area. We have combined these measures into an index of social class (23). This index was developed in a blatantly post hoc fashion which maximized the degree to which class is associated with variation in the various pathologies. Our index of ethnicity is also based on three measures: a) the percentage of Negroes in the Community Area, b) the percentage of Puerto Ricans in the Community Area, and c) the percentage of foreign-born in the Community Area. Again this index was developed in a post hoc fashion which maximized the degree to which ethnicity is associated with variation in the various pathologies (24).

We would note that by maximizing the explanatory power of class and ethnicity we are diminishing the likelihood that we would accept density as a significant variable.

Preliminary Results. Table 1 exhibits, for each of the measures of social pathology, four different correlation coefficients. In Panel A of the Table, the relationship of population density and social pathology is explored; Panel B addresses the more traditional problem of the relationship between social class and social pathology.

The causal model implicit in the Calhoun type of argument is simply that



For this model a relevant measure is the set of zero order correlations between density and the five pathologies (25). These are presented in the first row of Table 1. It is immediately noted that for each social pathology, the relationship with density is significantly different from zero, but that it is relatively small. Furthermore, one of the five coefficients, though significant, is in the wrong direction. That is, the animal studies consistently indicate that the higher the population density, the lower the level of fertility. Here, the relationship is positive: the higher the density, the higher the fertility. However, some investigators might want to argue that high rates of fertility are pathological for urban populations (26). Thus, from the first row of Table 1, one might conclude that population density has a small but significant effect on social pathology: the higher the density, the higher the pathology.

We know, however, that the lower one's social class and ethnic status the more likely one will live in areas with a high population density. Thus, it may be that class and ethnicity account for both the variations in population density and pathology and that there is no causal relation-

may affect density, and density may, in turn, affect the pathologies. In this case density partially 'interprets' how class and ethnicity relate to the pathologies. In this latter instance we assume that class and ethnicity also affect the pathologies in ways unrelated to density. These two possibilities are presented in Figure 1. We now turn to their evaluation.

Figure 1 about here

If the relationship between density and pathology is spurious, then when we control for class and ethnicity, the partial correlation between density and pathology should approach zero. In contrast, if density is an intervening variable, the partial correlation between density and pathology will not go to zero when class and ethnicity are used as controls, although it may be reduced. Furthermore, if density is a major intervening variable the partial correlation between the social structure variables and pathology would be noticeably reduced when density is used as a control.

As is apparent from the second row of Table 1, when class and ethnicity are used as controls, the correlations between density and the pathologies are not significantly different from zero. Furthermore, as is shown by Panel B of Table 1, controlling for density has virtually no effect on the correlation between the social structure variables and the pathologies. One may assert then that these data indicate that the relationship between density and the pathologies is spurious (27). These results, we would note, are similar to Winsborough's who used 1950 data for Chicago (28).

Table 1 about here

The Dimensions of Population Density

However, before we accept such a conclusion, a reappraisal of our measure of density, persons per acre, may be in order. When the animal ecologists refer to overpopulation of a particular species they generally indicate the number of animals per some unit of area, such as an acre. However, in the case of human populations, the situation is substantially more complex, especially in an urban setting. On the one hand, there is what might be called overcrowding at the personal, or individual level. That is, is it possible for an individual to have privacy in the particular housing unit in which he resides, or is he constantly in contact with others. We refer to this type of overcrowding as "interpersonal press." As we have developed the concept, interpersonal press is composed of two logically distinct factors: a) the number of persons per room and b) the number of rooms per housing unit (29).

Levels of population density may also be affected by more "structural" factors. In the urban setting there is considerable variation in the type of structures persons live in and in the spacing of these structures. If each individual housing unit is a single, detached structure then there must be many individual structures per acre to achieve a high level of population density. Alternatively, if there are many high-rise apartment buildings in the area, then the number of housing units per structure will increase dramatically, and another measure, the number of residential structures per acre, may stay relatively low.

A given level of population density in a Community Area can be achieved by different combinations of four factors: a) the number of persons per room; b) the number of rooms per housing unit; c) the number of housing units

per structure; and d) the number of residential structures per acre.

Table 2 shows the interrelationships of the various measures of population density in Chicago ('30). The first column of Table 2 shows the zero-order correlations between the overall measure of population density -- persons per acre -- and the four dimensions of this overall level. The next column of Table 2 shows the results of a multiple regression analysis of the four dimensions of population density on the general measure of population density -- persons per acre. Both columns indicate that it is the structural measures of density -- housing units per structure and structures per acre -- which account for most of the variance in persons per acre while the measure of interpersonal press -- persons per room and rooms per housing unit -- have only a modest relationship to persons per acre.

Table 2 about here

These data thus suggest that the preceding analysis of the relationship between density and pathology may have yielded misleading conclusions. This is particularly obvious if the effect of density on pathology is primarily in the area of interpersonal crowding. Therefore we will reanalyze the relationship between density and pathology by decomposing persons per acre into its four component parts.

We are still essentially testing the two models outlined in Figure 1 with the one difference that, as density has been decomposed into four components, our density measure is now a multiple R. As before, if the relationship between the components of density and the pathologies is spurious, when we control for class and ethnicity, the multiple-partial

correlation between density and pathologies should approach zero, but if density is an intervening variable, the multiple-partial correlation should not go to zero, although it may be reduced in size. The importance of density as an intervening variable should be directly related to the reduction of the multiple-partial correlation between the social-structural variables and the pathologies when density is used as a control.

As is shown in Table 3, the results of the analysis when population density is decomposed into its four dimensions is strikingly different from the original analysis shown in Table 1. Density is now strongly related to each of the pathologies, and in all cases a significant relationship between the density components and the pathologies remains when class and ethnicity are used as controls. Furthermore, the relationship between the social structure variables and the pathologies is markedly reduced when the components of density are used as a control. From this revised analysis it appears that at least some of the density components intervene between class and ethnicity and the various pathologies, thereby partially "interpreting" that relationship. In the remainder of the paper we will assume that this is correct, although we would emphasize that we have not proved that this is the case. For example, we are simply assuming that class and ethnicity "cause" density and thereby ignore the possibility that density (through selective migration) "causes" class and ethnicity.

With the posited model in mind, let us attempt to evaluate the contributions made by class, ethnicity, and the four components of density. Following Duncan (31) we can do this in two different ways. First, we can work back from effect to cause. In this case the multiple correlation

between the components of density and pathology represents the total 'effect' of density including both its 'unique' contribution to the variance of the pathology in question and the contribution it 'transmits' from the social structure variables, class and ethnicity. The increment added by class and ethnicity that is not 'routed' through density can be calculated by subtracting the variance explained by density from the variance explained by density, ethnicity, and class. Alternatively, we can go from earliest cause to effect. In this case the multiple correlation of ethnicity and class with pathology represents the total effect of these social structure variables, including the effect 'routed' through density. We can then calculate the independent effect of density (the effect that is unrelated to ethnicity and class) by subtracting the variance explained by ethnicity and class from the variance explained by density, ethnicity, and class.

The results of the analysis just outlined are presented in Table 4. If we work back from effect to cause, density appears to 'account' for most of the variance, with the social system variables having relatively little effect on the pathologies except through their effect on the components of density. On the other hand, if we go from earliest cause to effect we see that class and ethnicity do, at least indirectly, account for most of the variance of the pathologies. It is noteworthy that in most cases the independent increment of explained variance added by either the social structure variables or by the density components is fairly small.

As a step towards identifying the relative importance of each of the four components of population density a multiple regression analysis was run on the five social pathologies. In four of the five cases the

standardized regression coefficients indicated that the number of persons per room is the most important determinant of the effect of density on pathology. The exception is admission to mental hospitals where the dimension of pathology which is most important is the other measure of interpersonal press -- rooms per housing unit. Next, we found that in four of the five cases the second most important component is housing units per structure. When an analysis comparable to that outlined in Table 4 is performed comparing the effect of persons per room and rooms per housing unit when class and ethnicity are taken into account, the results are strikingly similar. That is, the values differ only slightly from those in Table 4, where all four components of density are considered.

Table 5 presents a similar analysis but with only one dimension of density considered -- persons per room. As we already suspect that persons per room is not strongly related to admission to mental hospitals we will first focusour attention on the other four pathologies. For these pathologies the total amount of explained variance has dropped only a relatively slight amount. As we move from effect to cause we find that our single dimension of density, persons per room, accounts for most of the explained variance, although the relationship is not as strong as when we used four dimensions of density. However, compared to our prior analysis there is a noticeable increase in the independent increment added by class and ethnicity. Most of this increase can be attributed to the fact that housing units per structure are no longer treated as part of density.

This analysis suggests that for mortality, fertility, public assistance, and juvenile delinquency, the most important dimension of density is persons per room. Next, but considerably less important is the number of housing units per structure. For these four pathologies the

other two dimensions of density -- rooms per housing unit, and structures per acre -- appear to be relatively unimportant.

The pattern is quite different for admissions to mental hospitals. When Table 5 is compared with Table 4 it is readily seen that there is a marked decline in the total amount of variance explained, when the only dimension of density considered is persons per room. This is not surprising since the standardized regression coefficients indicate that rooms per housing unit is the most important component of density. In Table 5 we have put in parentheses the variance associated with rooms per housing unit. Comparing these with those obtained when the four dimensions of density are used it is apparent that rooms per housing unit can account for virtually all the variance in hospital admissions associated with density.

If our assumptions are correct, these data indicate that density - particularly persons per room (except in the case of admissions to mental hospitals) - may be an important factor in the development of various pathologies. Before concluding, let us briefly discuss the mechanisms by which density may relate to the pathologies under consideration.

How Density May Relate to Pathology

Before considering each pathology separately, let us make some general observations. First, as the number of persons in a dwelling increases so will the number of social obligations, as well as the need to inhibit individual desires. This escalation of both demands and the need to inhibit desires would become particularly problematic when people are crowded together into a dwelling with a high ratio of persons per room. Second, crowding will bring with it a marked increase in stimuli that are difficult to ignore. Third, if humans, like many animals, have a need for territory

or privacy, then overcrowding may be in fact conflict with a basic (biological?) characteristic of man (32).

It would seem reasonable to expect that persons would react to the incessant demands, stimulation, and lack of privacy resulting from overcrowding with irritability, weariness and withdrawal. Furthermore, persons are apt to be so completely involved in reacting to their environment that it becomes extremely difficult for them to step back, look at themselves, and plan ahead (33). It would certainly seem that in an overcrowded situation it would be difficult for persons to follow through on their plans. Thus, in an overcrowded environment we might expect the behavior of people to be primarily a response to their immediate situation, and to reflect relatively little regard for the long range consequences of their acts.

It would seem apparent from the above discussion that the most important dimension of density, as far as the pathologies are concerned, would be persons per room. This, of course, is the dimension our analysis indicated is most important. Furthermore, if we focus on the interaction between persons in different dwelling units, it would seem that, to the degree such persons were involved with each other because of spatial arrangements (i.e., could hear arguments, television, etc.), many of the reactions that occur in the interpersonal level, such as irritation and withdrawal, might also occur at this level of interaction. Probably the most relevant indicator regarding overcrowding for this level of interaction is housing units per structure. And this, in our analysis, was the second most important dimension of density.

Now let us turn to a brief discussion of the possible effect of density (overcrowding) on each of the five pathologies under consideration.

Mortality. There are at least four possible ways in which crowding may be related to mortality. First, increased contact with others increases one's chances of contracting various infectious diseases. Such contact would presumably be related to both the number of persons per room and the number of housing units per structure. Second, if persons do become tired and run down due to overcrowding (34), overcrowding would increase a person's susceptibility to disease. Third, sick persons in an overcrowded situation are apt to be constantly disturbed by the activity of others and thus will often not get the rest and relaxation which is an important component of the treatment. And fourth, if overcrowding is associated with irritation, withdrawal, and ineffectual behavior, the treatment the sick person receives (from family members) will not be as effective in an overcrowded situation. Regarding the above points we would note that investigations of overcrowding do reveal a relationship with poor health (35) and that controlled studies confirm that improved housing reduces the incidence of illness and death (36).

Fertility. The animal studies that report changes in natality accompanying overcrowding indicate that overcrowding leads to a drop in the natality rate. However, we found the exact opposite, namely the greater the density the greater the fertility. If we are to take the animal studies as having relevance for humans, we must reconcile this difference. We reiterate that although density has an important impact on many animals, both the effects of density and the mechanisms involved differ widely from species to species. Second, we note that a frequent effect of overcrowding

among animals is the development of hypersexuality (37). Among humans an increase in sexual intercourse is likely to lead to increased natality for humans are receptive twelve months of the year. In contrast, most female animals are receptive during a very specific and limited time period and at this time they routinely have sexual intercourse. Therefore there is no reason to believe that increased rates of sexual intercourse among most animals would typically lead to increased natality rates, while it would among humans. Third, we note that many factors that would appear to limit natality in animals, such as lack of territory (38), or intense social competition (39), do not appear to be a major factor in human populations. Fourth, as overcrowding appears to make it difficult to step back, look at one's situation, and plan ahead, it may be that persons in overcrowded situations are less likely to perceive the long range consequences of having more children and are thus less likely to want to use birth control techniques. And finally, because overcrowding makes it difficult to follow through on plans birth control, even if desired, may be ineffectually practiced.

Ineffectual Parental Care (Public Assistance). Overcrowding may lead to tensions and irritations in the home. Potentially, this might result in the break up of the family which might also mean the loss of financial support. Even if the family does not break up, children may receive less effective care in the home because overcrowding leads to ineffectual performance and withdrawal on the part of the parents. Furthermore, in overcrowded situations parents may be less likely to support their children in the usual societal manner (through holding down a job) because weariness, poor health, and ineffectual ways of behaving which affect their performance in the larger community.

Juvenile Delinquency. As noted above, in an overcrowded environment parents are apt to be irritable, weary, harassed, inefficient. Children, in turn, are apt to find the home a relatively unattractive place, full of constant noise and irritation, with no privacy, no place to study, etc. They are thus apt to seek relief by getting out of the home. And, in fact, their disappearance may be partially welcomed by the parents for it removes (temporarily) a source of irritation. Studies of low income (overcrowded) families indicate, as our analysis would suggest, a strikingly early cut off point in parental will and ability to contain children (40).

An important component in the development of delinquent gangs appears to be a high degree of autonomy. We have suggested that such autonomy is apt to be greater in a dwelling with a high persons per room ratio. It may also be that autonomy is greater where there are a large number of housing units per structure which, as we have already argued, may lead to a decrease in communication between persons in different dwelling units. At any rate, the Chicago data indicate that housing units per structure has more "impact" on delinquency than it does on the other pathologies.

Psychiatric Disorder. From the above discussion, it would seem reasonable to anticipate a fairly strong relationship between persons per room and admissions to mental hospitals. However, persons per room has a much weaker relationship with admission to mental hospitals than it does with the other pathologies. In fact, the density component with by far the strongest relationship to admissions to mental hospitals is rooms per housing unit which does not fit readily into our framework.

Admissions to mental hospitals is highly correlated with the percent of persons living alone ($r = .72$) (41). It may be that isolation is a

contributing factor in the development of mental illness (too little interaction instead of too much). Furthermore, disturbed persons living by themselves are more likely to require hospitalization when they can no longer care for themselves than are persons living with and assisted by others. We suspect, however, that the correlation between rooms per housing unit (or persons living alone) involves primarily a self-selection factor. That is, people who have a history of having difficulty getting along with others are likely to move to small apartments where they live by themselves, and that these are the persons who are most likely to be admitted to mental hospitals. If this is the case, then it is the type of housing that has drawn disturbed persons into particular community areas. This would involve a process that falls completely outside the posited model. It may, of course, be that overcrowding played a role in the creation of the person's initial disorder which in turn led to him living alone, but these data, while not denying that possibility, do not support it.

Conclusion.

The present study suggests that overcrowding may have a serious impact on human behavior and that social scientists should consider overcrowding when attempting to explain a wide range of "pathological" behaviors. Having made this point, we end on a note of caution. We have been using cross sectional ecological data. Thus, not only have we not proved there is a causal relationship between density and the various pathologies, but the relationships that appear at the ecological level may not appear at the individual level. We would also note that although social structure variables and density are analytically very distinct, they are also highly

intercorrelated, at least for these data, that it is difficult to accurately identify their independent effects. Even assuming that the data on Chicago do reflect the importance of density, more research is needed. At the moment we may speculate (as we did) about how overcrowding may relate to various pathologies, but specific knowledge about causal links (if any) is lacking.

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18. These are ecological data, and relationships that occur at this level of analysis do not necessarily occur at the individual level. However, it seems to us that ecological measures are appropriate and meaningful when dealing with phenomena such as density. That is, characteristics of areal units may have a significant effect on rates of human behavior

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21. E. Kitagawa and K. Taeuber, ibid.

22. As noted, there are 75 community areas in Chicago. However, the central business district (Community Area 32--known as the Loop) is a highly unique area with regards to various social economic, and other kinds of indicators. In our case the measures of pathology are dramatically changed if the central business district is included. Perhaps the most marked case is the rate of Admissions to Mental Hospitals, where the city-wide rate is 297.6. The rate for the Loop is 3,757.2, and the next highest rate is 851.1. While the elimination of the Loop does not transform the distribution of Admissions to Mental Hospitals into a normal distribution, it does substantially reduce its deviation from this ideal: skewness is reduced from 7.56 to 2.88 and kurtosis is reduced from 62.32 to 15.14 (for a discussion of skewness and kurtosis see J. Freund, Modern Elementary Statistics (Prentice-Hall, Englewood Cliffs, 1960), pp. 99-105. Other measures, especially the Standardized Mortality Ratio, are affected in similar although somewhat less drastic fashion. For this reason the following analysis is based on 74 rather than 75 Community Areas in Chicago around 1960.

(References and Notes continued)

23. A regression analysis of income, education, and occupation was run on each of the pathologies. These five regression equations were then used as a basis for constructing the weighted sum of the three measures as general index. The equation for the indexed social class is as follows: INDEX OF SOCIAL CLASS = 0.1* (Median Family Income) + 10.0* (Median Years of School Completed) + (Per Cent Employed Males in White Collar Occupations) - 550.0.

    As it is not obvious from the equation, we would note that median family income is by far the most important component of the social class index.

24. A regression analysis of percent black, percent Puerto Rican, and percent foreign born was run on each of the pathologies. As with social class, these five regression equations were then used as a basis for constructing the weighted sum of the three measures as a general index. The equation for the index of ethnicity is as follows:

    INDEX OF ETHNICITY = 25.0* (percent Negro) + 10* (percent Puerto Ricans) + 0.1* (percent foreign born)

    As is not immediately obvious from the equation, we would note the percent Negro is by far the most important component of the ethnicity index.

25. As Blalock notes, grouping by proximity may partially control for independent variables associated with "error" in the dependent variable. Thus to some extent, the size of the correlation between density and the pathologies and the social structure variables and the pathologies may be determined by the fact that the community areas like all ecological variables, involved data grouped by proximity. H. Blalock, Causal Inferences in Nonexperimental Research (University of North Carolina, Chapel Hill, 1964), pp. 102-114.

(References and Notes continued)

26. In another section of the paper we will discuss the possibility that in human populations high rates of fertility might be a consequence of population density.

27. The same conclusion is reached if one uses regression coefficients. We would note that there are advantages and disadvantages to using either regression coefficients or partial correlation. Although multiple partial correlations are not strict estimates of the parameters of the causal model for our purpose we consider them to be sufficient and their use will simplify the analysis in the second part of the paper.

28. H. Winsborough, in Social Demography, T. Ford and G. De Jong, Eds. (Prentice-Hall, Englewood Cliffs, 1970), pp. 84-90.

29. Holding the number of persons per room constant, it is probably the case that an increase in the number of rooms increases the likelihood that a person will be able, at least occasionally, to be alone in a room.

30. The number of persons in each Community Area is reported directly in the Local Community Fact Book, as is the number of housing units. The number of rooms per Community Area, and the number of residential structures per Community Area are, however, based on estimates from open-ended interval data. The Fact Book reports the number of housing units with 1,2,3,4,5,6,7, and 8 or more rooms in them. To get an estimate of the number of rooms per Community Area, we multiplied the number of housing units at each level with the appropriate number of rooms. The highest interval was multiplied by 8, even though it was an open-ended interval. The Fact Book reports the number of housing

(References and Notes continued)

30. (Continued)

units in 1-unit structures, 2-unit structures, 3 and 4-unit structures, 5 to 9-unit structures, and 10 or more unit structures. Data from the 1940 Fact Book suggest that for that year slightly over half of the housing units located in the over 10 category were in the over 20 category. To estimate the number of residential structures in the area, we set the mid-interval points for these data at 1,2,3,5,7, and 20. We divided the number of housing units in each category by these mid-interval points, and summed the resulting figures to get the estimate of the number of residential structures for the Community Area. The four measures of density were then calculated by division: number of persons divided by the number of rooms, the number of rooms divided by the number of housing units, etc.

31. O. Duncan, in Sociological Methodology, E. Borgatta and G. Bohrnstedt, Eds. (Jossey-Bass, San Francisco, 1970), pp. 38-47.

32. R. Sommer, Personal Space (Prentice-Hall, Englewood Cliffs, 1969).

33. J. Plant, American Journal of Psychiatry 9, 849-860 (1930); in Modern Introduction to the Family, N. Bell and E. Vogel, Eds., pp. 510-520.

34. A. Davis, in Industry and Society, W. Foote Whyte, Ed., pp. 84-106.(1946).

35. A. Pond, in Marriage and Family Living 19, 154-159 (1957); D. Wilner et al., American Journal of Public Health 46, 736-744 (1956).

36. D. Wilner et al., The Housing Environment and Family Life: A Longitudinal Study of the Effects of Housing on Morbidity and Mental Health (John Hopkins Press, Baltimore, 1962).

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37. J. Calhoun, Scientific American, 139-148 (1962); Y. Susiyama, in Social Communications Among Primates, S. Altmann, Ed. (University of Chicago Press, 1967).

38. A. Watson, Nature 215, 1274-1275 (1967).

39. L. Mech, The Wolf: The Ecology and Behavior of an Endangered Species (The Natural History Press, Garden City, 1970.

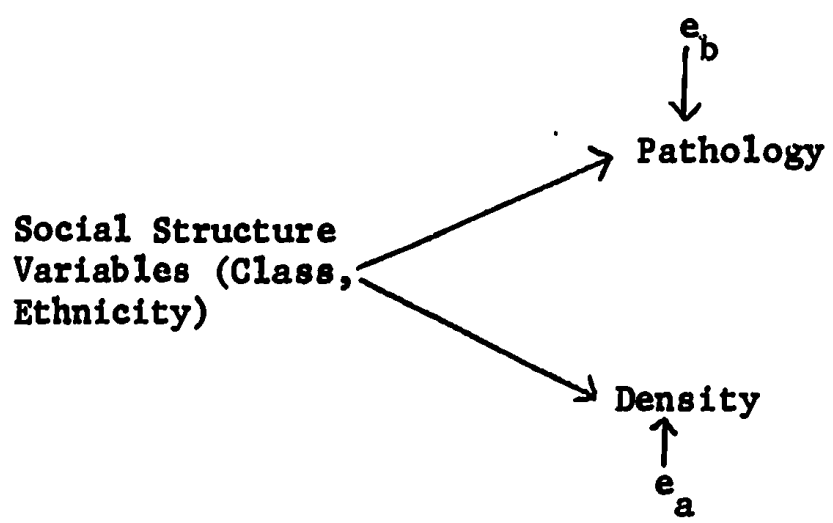
40. H. Lewis, Child Rearing Practices Among Low Income Families in the District of Columbia, presented at the National Conference on Social Welfare, Minneapolis (1961). Mimeographed; S. Riemer, American Sociological Review 8, 272-278 (1943); R. Mitchell, American Sociological Review 36, 18-29 (1971).

41. The relationship between percentage of persons living alone and admissions to mental hospitals remains fairly strong even after class and ethnicity are used as controls ($r = .59$). We would also note that percentage of persons living alone has a high negative correlation with rooms per housing unit ($r = -.91$).

42. The research for this paper was supported in part by the Urban and Regional Development Center, Vanderbilt University. We thank Herbert Costner, Leo Rigsby, Antonina Gove, and Otis Dudley Duncan for their comments on an earlier draft of this paper.

Figure 1

Density as a spurious relationship



Density as an intervening variable

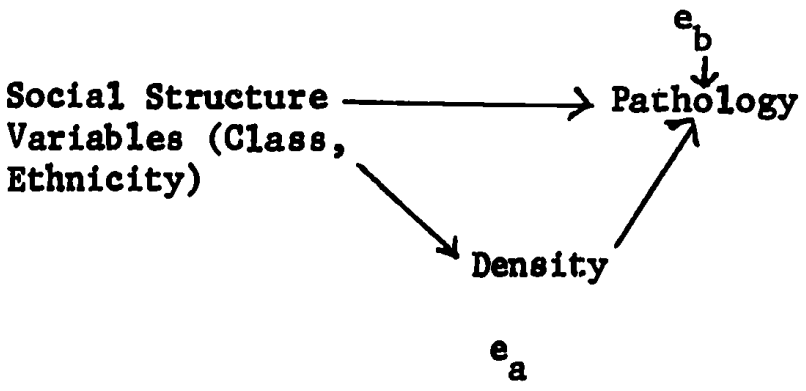


TABLE 1 - Social Pathology, Population Density, Ethnicity, and Social Class: Zero-Order, Multiple, and Partial Correlation Coefficients - Chicago, 1960

(A) Population Density and Social Pathology	Social Pathologies				
	Standard Mortality Ratio	General Fertility Rate	Public Assistance Rate	Juvenile Delinquency Rate	Admissions to Mental Hospitals
Zero-Order Correlation Coefficient of Each Pathology with Population Density*	.283	.373	.337	.492	.349
Partial Correlation Coefficient of Each Pathology with Population Density, Controlling for Social Class and Ethnicity	-.177**	-.023**	-.118**	.227**	.142**
(B) Social Class, Ethnicity, and Social Pathology					
Multiple Correlation Coefficient of Each Pathology with Social Class and Ethnicity	.828	.853	.885	.927	.546
Multiple-Partial Correlation Coefficient of Each Pathology with Ethnicity and Social Class, Controlling for Population Density	.817	.827	.871	.907	.466

* The measure of density - persons per acre - is transformed into natural logarithms

** Not significantly different from zero at p = .05

TABLE 1 The Interrelationships Among the Dimensions of Population Density: Chicago, 1960*

	The Four Dimensions of Population Density			
	Persons per room	Rooms per Housing Unit	Housing Units per Structure	Structures per Acre
Zero-Order Correlations with Persons per Acre	.146	-.560	.741	.717
Standarized Regression Coefficients from a Multiple Regression Analysis of the Four Dimensions of Population Density on Persons per Acre	.226	.242	.811	.699

* All measures of density are transformed into natural logarithms. Since this is the case, the multiple regression analysis of the four dimensions of density on persons per acre yields a multiple R of 1.00, and the unstandardized regression coeffcients are also 1.00.

TABLE 3 - Social Pathology, Density, Ethnicity, and Social Class Reexamined

(A) Population Density and Social Pathology	Social Pathologies				
	Standard Mortality Rate	General Fertility Rate	Public Assistance Rate	Juvenile Delinquency Rate	Admissions to Mental Hospitals
Multiple Correlation Coefficients of the 4 Dimensions of Density* on Each of the Social Pathologies	.867	.856	.887	.917	.689
Multiple-Partial Correlations Coefficient of Each Pathology with the 4 Dimensions of Density, Controlling for Ethnicity and Social Class	.476	.371	.584	.498	.508
(B) Social Class, Ethnicity, and Social Pathology					
Multiple Correlation Coefficient of Each Pathology with Social Class and Ethnicity	.828	.853	.885	.927	.546
Multiple-Partial Correlation Coefficient of Each Pathology with Ethnicity and Social Class, Controlling for the 4 Dimensions of Population Density*	.143**	.351	.574	.574	.086**

* All measures of density are transformed into natural logarithms

** Not significantly different from zero at P = .05

TABLE 4 - The Proportion of Variance Explained by the Four Components of Density and by Class and Ethnicity

	Social Pathologies				
	Standard Mortality Ratio	General Fertility Rate	Public Assistance Rate	Juvenile Delinquency Rate	Admissions to Mental Hospitals
Working Backward From Effect to Cause					
Total 'effect' of the four components of density	75.2	73.3	78.7	84.1	47.5
Increment added by class and ethnicity	.4	3.2	7.0	5.3	.4
Total Variance explained	75.6	76.5	85.7	89.4	47.9
Working Forward From Prior Cause to Effect					
Total 'effect' of class and ethnicity	68.5	72.8	78.3	85.9	29.8
Increment added by the components of density	7.1	3.7	7.4	3.5	18.1
Total Variance explained	75.6	76.5	85.7	89.4	47.9

TABLE 5 - The Proportion of Variance Explained by Persons per Room and by Class and Ethnicity

	Standard Mortality Ratio	General Fertility Rate	Public Assistance Rate	Juvenile Delinquency Rate	Admissions to Mental Hospitals	
Working Backward from Effect to Cause						
Total 'effect' of persons per room	60.5	65.4	73.3	61.5	15.8	(46.8)*
Increment added by class and ethnicity	9.8	9.5	10.1	24.4	15.6	(.2)
Total variance explained	70.3	74.9	83.4	85.9	31.4	(47.0)
Working Forward From Prior Cause to Effect						
Total 'effect' of class and ethnicity	68.5	72.8	78.3	85.9	29.8	(29.8)
Increment added by persons per room	1.8	2.1	5.1	0.0	1.6	(17.2)
Total variance explained	70.3	74.9	83.4	85.9	31.4	(47.0)

* The numbers in parentheses indicate the values that occur when rooms per housing unit are used instead of persons per room